

satisfactory. Therefore, the solid solution interface existing in the film causes no problem for electron reflection. In the presence of the fcc-structured Au/Cu underlayer, the layer of CoFe was well oriented in fcc(111) orientation. In addition, the d(111) spacing in CoFe is 0.2074 nanometers, and the magnetostriction therein was controlled to be small.

The cross section of the spin valve film of this Example 1 was observed through TEM (transmission electron microscopy). As a result, it was confirmed that the GMR basic unit moiety of CoFe/Cu/CoFe was formed on the underlayer of Au/Cu in regular layer by layer, and was oriented in fcc(111) orientation. In microdiffraction of the free layer, CoFe layer part, the fcc-d(111) spacing was found 0.2074 nanometers. The spacing is favorable to magnetostriction control. Fig. 48 shows the XRD pattern of the spin valve film. Through the X-ray diffraction of the film, the fcc-d(111) spacing in CoFe was found 0.2074 nanometers.

In the XRD profile in Fig. 48, the peaks 1, 2 and 3 are for IrMn, and the peak 4 will be the fcc(111) peak for the laminate film of CoFe/Cu/CoFe. The d-spacing in the free layer only is difficult to determine. In this case, the d-spacing for the peak 4 is considered as the d-spacing in the free layer.

In place of the underlayer of 1 nm Au/1 nm Cu, when a underlayer of 2 nm Cu only was used, then the fcc-d(111) spacing in CoFe decreased to 0.2054 nanometers and the magnetostriction

increased in the negative side. On the other hand, when a underlayer of 2 nm Au only was used, then the fcc-d(111) spacing in CoFe increased to 0.2086 nanometers and the magnetostriction increased in the positive side. Only when the underlayer of Au/Cu was used, the suitable spacing of 0.2074 nanometers was realized.

The thermal stability of the prior art film (g) where the underlayer is of Cu is not good. However, the thermal stability of the film of this Example where the underlayer is of a laminate film of Au/Cu is good. One reason will be because of the difference in the lattice spacing between the two which will have some influence on the magnetostriction of the films. Precisely, the lattice spacing is narrowed on the Cu underlayer, whereby the lattice unconformity in the interface to IrMn is augmented and the distortion is enlarged. When the film with such large distortion is annealed, the distortion is relaxed whereby the interface between the pinned magnetic layer and the antiferromagnetic film becomes diffusive. This influence is larger when the IrMn layer is thicker. On the other hand, the lattice spacing in the underlayer of Au/Cu is nearer to that in IrMn. Therefore, the film of CoFe/Cu/CoFe to be laminated on the Au/Cu layer is, contrary to the case having the simple Cu underlayer, to have a distorted lattice of which the lattice constant is near to that of IrMn. As a result, the influence of annealing on the distortion relaxation in the

case having the laminate underlayer of Au/Cu will be smaller.

In the other prior art constitution (h) having an Au underlayer, the lattice spacing is larger, contrary to that in (g). In the case (h), therefore, the distortion energy of CoFe/Cu/CoFe is too large so that the interfacial dislocation occurs with ease. As a result, the film (h) is degraded in initial annealing. When the Au layer is directly laminated on the CoFe layer, Au will diffuse even into the nonmagnetic spacer layer of Cu while passing through the intergranular boundaries. If Au reaches the nonmagnetic spacer layer, the MR ratio in the film immediately decreases. The MR ratio reduction worsens the long-term thermal stability of the film. However, if the laminate film of Au/Cu is disposed as the underlayer below CoFe, the Cu layer acts as a stopper to prevent Au diffusion, and the long-term thermal stability of the film is thereby stabilized.

The underlayer of Ta is a buffer layer necessary for two-dimensional growth of Au. If Au is directly formed on amorphous  $\text{Al}_2\text{O}_3$ , it will island-wise grow. In that condition, where the pinned magnetic layer and the free layer are magnetically coupled to each other via the spacer layer,  $H_{in}$  will increase. In producing practical devices, the films are formed on processed substrates. For the devices, therefore, the buffer layer is indispensable for stable film formation. In this Example, Ta was used for the underlayer. Apart from